Security paper and method for producing the same

[0001] This invention relates to a security paper for producing value documents, such as bank notes, passports, identification documents or the like, having a flat substrate provided at least partly with a dirt-repellent protective layer for extending the life time and fitness for circulation. The invention further relates to a value document having such a security paper and to a method for producing such a security paper.

[0002] Value and security prints, such as bank notes, shares, bonds, certificates and coupons, checks, high-quality admission tickets, but also other papers at risk of forgery, such as passports, or other identification documents, are often provided with elaborate printed images to increase their falsification security. Printing processes that are technically sophisticated and not accessible to everyone, such as intaglio printing, are used at least for some of the picture elements here.

[0003] Additionally, the security prints are frequently equipped with so-called security elements which are difficult to imitate and permit even a layman to check the authenticity of the print or the document. Such security elements can be for example windowed security threads which are visible in certain areas on the surface of the paper of value, applied foils which have a transparent or metallized embossed hologram, blind embossings, so-called "latent images" produced by printing technology or by printing and embossing technology which render different information from different viewing angles, prints containing optically variable pigments and producing different color effects depending on the viewing angles, or prints comprising metallic effect ink which have metallic luster for example in a gold, silver or bronze tone.

[0004] An important component of value documents, such as bank notes, is their flat substrate which preferably consists predominantly of cotton paper and whose typical haptics is also influenced by the one-sided or two-sided calendering during steel engraving. The haptic character of a bank note is manifested mainly by its feel and its flexural stiffness; it furthermore has a characteristic sound when being deformed and creased.

[0005] It is known to provide papers of value with a dirt-repellent protective layer to extend the life time and fitness for circulation. For example, the print EP 0 256 170 B2 proposes providing printed bank notes with a protective layer which contains cellulose ester or cellulose ether for the greater part and micronized wax for a lesser part and which is applied to the bank notes all over. The micronized wax is dispersed by kneading or mixing with oil, an ink binder or a mixture thereof. The sheets freshly printed with the protective layer can be stacked without difficulties without any black ink from one sheet staining the sheet therebelow.

[0006] The print WO 00/00697 discloses a security paper for bank notes having a dirt-repellent coating which despite the coating remains largely unchanged in its typical properties, such as printability, sound and color, compared to an uncoated paper. A coating composition containing only a binder and no fillers is applied to the bank note paper, which has a large surface area or high surface roughness due to its porosity. The composition is applied in a layer thickness such that a smooth surface and thus little possibility for dirt deposit results, on the one hand, and the coating is thin enough not to impair the other stated properties of the paper, on the other hand.

[0007] Known protective layers have in common that the wearing protection is not particularly high. Conventional protective layers comprising water-based lacquers usually fail to completely meet a demanding requirement profile. For example, very good dirt repellence and adhesion quality go against resistance to the penetration of liquid, and vice versa. Water-based lacquers therefore currently meet the high requirements for a protective layer in security printing and in particular bank-note printing only if a second component in the form of a crosslinking agent is added. Since such crosslinking agents are very reactive themselves, the operating staff must be sensitized to risks and suitable protective measures taken.

[0008] The invention is therefore based on the problem of specifying a security paper and method for producing it which avoids the disadvantages of the prior art. In particular, the security paper should have a longer life time due to good dirt repellence and high resistance to the penetration of liquid.

[0009] This problem is solved by the security paper having the features of the main claim. A value document and a method for producing a security paper are the subject matter of the coordinated claims. Advantageous developments of the invention are the subject matter of the subclaims.

[0010] According to the invention, the protective layer comprises at least two lacquer layers, a first lower lacquer layer being formed by a physically drying lacquer layer applied to the substrate which makes contact with the substrate therebelow and closes its pores, and a second upper lacquer layer being present which protects the substrate from physical and chemical influences and ensures good protection against the penetration of liquids and ink penetration.

[0011] The invention is based on the finding that the advantageous properties of radiation-curing lacquers can also be used for security papers if the depressions, uneven areas and pores of the substrates are previously closed by a physically drying lacquer layer. Radiation-curing lacquers and in particular UV-drying lacquers (hereinafter "UV lacquers") have the disadvantage that residual monomers and free photoinitiators as a rule remain as very reactive components in the depressions and pores of the substrate after radiation curing in dependence on the substrate quality, the radiated power, the initiator system and the monomer system (UV: ultraviolet).

[0012] This problem occurs increasingly when the UV lacquer penetrates into a paper fiber composite of e.g. a security paper. Complete polymerization of the UV lacquer is then no longer possible. It has now been found that the positive properties of UV lacquering can be fully exploited for security papers if a combination coating comprising at least two lacquer layers is used in which a lower lacquer layer makes contact with the substrate and closes its pores, and the upper lacquer layer applied is a layer protecting the substrate from physical and chemical influences.

[0013] The flat substrate of the security paper is formed in particular by an unprinted or printed cotton paper. The cotton paper of security and value documents, such as bank notes, has high porosity and surface roughness with microscopic projections and cavities where residual monomers and photoinitiators of the radiation-curing lacquer layer would be deposited without the inventive use of a lower lacquer layer.

[0014] The lower lacquer layer is advantageously formed by a water-based dispersion lacquer layer. It is expediently applied to the substrate in a layer thickness such that it forms a smooth and contiguous layer on the substrate. The lower lacquer layer is advantageously elastic, so as to avoid cracks from forming in the lacquer layer through mechanical motions or swelling of the fiber, e.g. through moisture absorption. This has the advantage of longer retaining the haptics typical of bank notes, that is, the flexural stiffness and sound, under stress. This has a positive effect in particular under extreme climatic and mechanical stress. The elastic lacquers preferably comprise polyurethane systems which give the lacquer its elasticity. These are in particular water-based dispersions of aliphatic polyester polyurethanes or styrene-acrylic polyurethanes. Obviously, the required amount of coating depends on the lacquer used, the substrate material used and its roughness and pore size and porosity factor, among other things.

[0015] The upper lacquer layer is preferably a radiation-curing and/or physically drying lacquer layer and particularly preferably comprises silicones and/or waxes to improve the dirt-repellent properties. In particular the radiation-curing lacquer layer is a UV-crosslinking lacquer layer (hereinafter "UV lacquer"). Its extremely high physical and chemical resistance permits a corresponding qualitative increase and adaptation of the requirement profile. The higher physical resistance causes in particular high abrasion resistance and an extension of the life time of the security paper. The higher chemical resistance furthermore makes the protective layer a long-term stable, effective barrier against water vapor and liquids, such as ink.

[0016] Additionally, the use of a UV lacquer offers a multitude of possibilities for selectively influencing the haptics of a security paper, in particular bank note. Adjusting the parameters of brittleness, luster and smoothness of the uppermost protective layer makes it possible to directly influence the haptic properties of the coated paper in diverse ways, in particular its flexural stiffness, smoothness and sound. The composition of the UV lacquer layer is advantageously selected particularly with respect to brittleness and surface tension so as to obtain a predetermined haptics of the security paper, in particular a predetermined smoothness, flexural stiffness and/or sound.

[0017] Apart from radically crosslinking UV lacquers, it is also possible to use cationically crosslinking lacquer systems for the radiation-curing lacquer layer.

[0018] The physically drying layer as the upper lacquer layer alternatively comprises water-based dispersions, preferably without a polyurethane component, e.g. based on styrene-acrylic.

[0019] It is likewise possible for the upper lacquer layer to contain a hybrid lacquer containing both physically drying components, such as a water-based dispersion lacquer component, and a radiation-curing lacquer component. During drying of the hybrid lacquer the water component is first removed physically, e.g. by heat, and then the radiation-curing lacquer component cured e.g. by means of UV radiation. Suitable hybrid lacquers are for example aqueous dispersions based on aliphatic urethane acrylates and suitable monomers or reactive oligomers, in particular acrylates with photoinitiators.

[0020] In a preferred embodiment, the upper lacquer layer is applied directly to the lower lacquer layer. Alternatively, a further lacquer layer comprising water-based dispersion lacquer can be provided between the upper and lower lacquer layers.

[0021] The lacquer layers of the protective layer are expediently coordinated with each other in their adhesion properties so as to form a highly resistant bond. In particular, when the upper lacquer layer is applied directly to the lower lacquer layer, the composition of the lower lacquer layer is selected so as to ensure optimal adhesion of the subsequently applied radiation-curing lacquer. In an advantageous embodiment, an optimization of the wettability of the lower lacquer layer is obtained by reducing the glass transition temperature of the lacquer system. This causes both higher adhesion and improved adhesion promotion.

[0022] According to further expedient embodiments, the upper lacquer layer or the lower lacquer layer is transparent and colorless. In particular if a printed substrate is to remain as readily visible as possible, both lacquer layers can also advantageously be formed to be transparent and colorless. The protective effect and the adjustability of the haptics of the security paper are still completely retained. However, it is also pos-

sible to color at least one of the lacquer layers. This permits the value document to be advantageously provided with a slight tint without any need to stockpile different substrate materials.

[0023] According to another advantageous embodiment, at least the upper lacquer layer has antibacterial fungus proofing.

[0024] It has further proved advantageous if the lower lacquer layer is present on the substrate in a coating weight of from 1 to 6 g/m², preferably 2 to 4 g/m². This corresponds for the preferred range to an amount of approx. 5 to 10 g/m² in the undried, wet state (e.g. aqueous dispersion lacquer with 40% solids content). In any case the layer thicknesses must suffice to close the irregular depressions and pores of the flat substrate. For the upper lacquer layer it suffices if it is present on the substrate with a slightly lower coating weight of from 0.5 to 3 g/m², preferably 1 to 2 g/m². This corresponds for the preferred range in the uncrosslinked state to an amount of approx. 1 to 2 g/m², since UV systems are so-called "100% systems" (100% solids content). With surfaces already smoothed and/or compressed by previous intaglio printing the values tend to be in the lower range, while with raw paper or the backs of intaglio printed pages they tend to be in the upper range.

[0025] According to an expedient development, the substrate is printed with characters or patterns and the protective layer is applied to the printed substrate. This also protects the print. The protective layer can also contain gaps, for example in the form of characters or patterns, in which optically variable elements or other security elements have been incorporated or will be incorporated at a later time.

[0026] According to a further preferred embodiment, the protective layer is applied to the substrate all over. It can likewise be expedient, as with a bank note for example, if the flat substrate of the security paper is provided with the dirt-repellent protective layer on its two main faces.

[0027] The invention also includes a value document, such as a bank note, coupon, certificate, passport, identification document or the like, which has a security paper of the described type.

[0028] For producing a security paper of the described type, a flat substrate is supplied in a step a), and a dirt-repellent protective layer applied to the substrate in a step b). The protective layer is applied by first applying a physically drying lacquer layer to the substrate as the lower layer of the protective layer to make contact with the substrate therebelow and close its pores in a step b_1), and applying a lacquer layer which protects the substrate from physical and chemical influences as the upper layer of the protective layer in a step b_2).

[0029] If a "wet-on-wet" application of the two lacquer layers is not possible, the lower lacquer layer is dried before the upper lacquer layer is applied. Drying can be effected simply during a sufficiently long waiting time, for example during transport of a sheet over a sufficiently long transport path. With regard to fast lacquering it is expedient in terms of production engineering and economy to accelerate physical drying by additional measures. For this purpose it is preferable to use dryers which have a hot-air blower and/or an infrared emitter.

[0030] The invention offers particularly great advantages if the flat substrate supplied is a printed or unprinted cotton paper.

[0031] According to a preferred embodiment, a printed image is printed on the substrate prior to application of the protective layer. Alternatively or additionally, a printed image can be printed on the lower lacquer layer after application of the lower lacquer layer to the substrate. The upper lacquer layer is then applied to the lower lacquer layer and to the printed image which is typically not all-over. It is of course also conceivable for the upper lacquer layer to be also printed.

[0032] The lower, upper or both lacquer layers are advantageously applied by a flexographic printing process. The lacquer layers are expediently thereby applied in an amount of coating of from 1 to 8 g/m². In another advantageous embodiment, the lower, upper or both lacquer layers are applied by a screen printing process. In this case the lacquer layers are expediently applied in an amount of coating of from 5 to 15 g/m². According to yet a further variant of the invention, it is provided that the lower and/or upper lacquer layer is applied by the offset printing process, by dry offset or by the indirect letterpress printing process.

[0033] According to a particularly preferred embodiment, the flat substrate supplied in step a) is a paper-of-value sheet comprising a multiplicity of single copies for which steps b), b_1) and b_2) are carried out at the same time. The lower and upper lacquer layers are applied to the substrate especially advantageously in-line, i.e. in one run, in a sheet-fed lacquering machine.

[0034] The apparatus for carrying out the described method preferably comprises a first lacquering module for applying the lower, physically drying lacquer layer to the substrate, an intermediate dryer for drying the lower lacquer layer, a second lacquering module for applying the upper lacquer layer, and a final dryer for curing and/or drying the upper lacquer layer.

[0035] To ensure constant layer thicknesses, the first and/or second lacquering module is formed by a flexographic printing unit with a chambered doctor blade, anilox roller and plate cylinder. The anilox roller advantageously has small cells whose volume and/or density determines the lacquer application rate. The chambered doctor blade lies against the anilox roller, filling the cells and scraping off surplus lacquer at the same time. The anilox roller transfers lacquer to the plate cylinder which is preferably formed by a rubber blanket. The rubber blanket finally transfers lacquer to the flat substrate, in particular a paper sheet or paper web.

[0036] Further, a lacquer conditioning device is preferably provided for adjusting the viscosity of the lacquer and the crosslinker concentration. For lacquers with radiation-curing components the lacquer conditioning device expediently has a tempering device for adjusting the viscosity and flow behavior of the lacquer. Since there are thus only two influencing variables for the lacquer application rate, namely cell volume and viscosity of the lacquer, such a flexographic printing unit with a chambered doctor blade permits realization of a lacquering method by which a uniform, homogeneous and cohesive lacquer film can be applied to the whole sheet reproducibly and over a very long time period.

[0037] The intermediate dryer is advantageously a controllable IR-hot air combination dryer (IR: Infrared). It is likewise expedient if two dryer modules are used in the intermediate dryer so that sufficient drying is guaranteed even at high speed. The final

dryer preferably has power-controlled UV drying modules which are coordinated with the wavelength required for curing the upper lacquer layer and with the layer thickness thereof.

Example 1

[0038] By flexographic printing the lower elastic lacquer layer is applied to a cotton paper with a 20 cm^3/m^2 roller at an application rate of approx. 2.0 g/m^2 dry in the lacquering unit 1. The elastic lacquer is an aqueous dispersion based on styrene-acrylic polyurethane (designation: L51073 from the company Pröll).

[0039] The upper, second lacquer layer is applied over the first lacquer layer with a 9 cm^3/m^2 roller at an application rate of approx. 1.8 g/m^2 dry in the lacquering unit 2. The second lacquer is a UV lacquer (designation: UV L50733 + UV L50734, mixing ratio 3: 2, from the company Pröll).

Example 2

[0040] The two-ply coating is produced as described under Example 1, with the exception that a 20 cm^3/m^2 roller is used and the lacquer applied at an application rate of approx. 2.0 g/m^2 dry in the lacquering unit 2. The second lacquer is a hybrid lacquer (designation: L50807 + L50806, mixing ratio 1 : 1, from the company Pröll).

Example 3

[0041] By flexographic printing the lower elastic lacquer layer is applied to a cotton paper with a 13 cm^3/m^2 roller at an application rate of approx. 1.3 g/m^2 dry in lacquering unit 1. The elastic lacquer is an aqueous dispersion based on styrene-acrylic polyurethane (designation L51073 from the company Pröll). The upper second lacquer layer is applied over the first lacquer layer with a 13 cm^3/m^2 roller at an application rate of approx. 1.3 g/m^2 dry in the lacquering unit 2. The second lacquer is a styrene-acrylic-based aqueous dispersion.

[0042] Further embodiments as well as advantages of the invention will be explained hereinafter with reference to the figures. For more clarity, the figures do without a representation that is true to scale and to proportion.

[0043] Fig. 1 shows a detail of a cross section through a bank note with a two-layered protective layer according to one embodiment of the invention,

[0044] Fig. 2 shows the layer structure of the bank note of Fig. 1 in a schematic representation,

[0045] Figs. 3 and 4 show the layer structure of further designs of bank notes according to embodiments of the invention, and

[0046] Fig. 5 shows a schematic representation of a sheet-fed lacquering plant for performing the invention.

[0047] Figures 1 and 2 show in cross section the structure of a bank note 10 with a two-layered protective layer 14 according to one embodiment of the invention. The protective layer 14 applied to the paper fiber composite 12 of the cotton paper includes a lower lacquer layer 16 comprising a water-based dispersion lacquer and an upper lacquer layer 18 comprising a UV-curing lacquer applied thereto.

[0048] The lower lacquer layer 16 makes the necessary contact with the paper fiber composite 12 and at the same time closes its capillaries. The lacquer layer 16 is applied in an amount of coating so as to form a smooth and cohesive surface which ensures optimal adhesion of the subsequently applied UV lacquer.

[0049] The composition of the UV lacquer 18 is selected so as to obtain the desired haptic and dirt-repellent properties of the bank note. In particular, the brittleness of the UV lacquer is adjusted so as to yield desired haptics and sound of the bank note. The dirt-repellent properties of the bank note are determined substantially by the selected surface tension of the UV lacquer. The high physical and chemical resistance of the UV lacquer gives the bank note 10 high abrasion resistance and great resistance to the penetration of water vapor and liquids. The variability existing in the selection of the material parameters of the UV lacquer also makes it possible to realize new properties

with respect to haptics and sound of the bank notes that were hitherto hardly attainable in security printing.

[0050] In the embodiment of Figures 1 and 2 the water-based dispersion lacquer 14 is applied to the cotton paper 12 in a coating weight of 3 g/m², the UV lacquer 18 in a coating weight of 1.5 g/m². The water-based dispersion lacquer 14 has a styrene-acrylic polymer and the UV lacquer 18 an acrylate system in this embodiment.

[0051] While the representations of Figures 1 and 2 show the protective layer 14 on an unprinted paper, the substrate 12 can obviously also be already printed. This is shown schematically in Fig. 3. Therein a printed image 20 comprising characters or patterns is printed on the cotton paper 12 of a bank note 10, and the protective layer 14 is applied to the printed image 20 and the substrate 12. Alternatively or additionally, a printed image 22 can also be disposed between the lower lacquer layer 14 and the upper UV lacquer layer 16, as shown in the representation of Fig. 4.

[0052] Fig. 5 shows a sheet-fed lacquering machine 30 for applying an inventive combination coating comprising two lacquer layers. The sheet-fed lacquering machine 30 comprises a lacquer conditioning device (not shown), two lacquering units 32 and 36, an intermediate dryer 34 and a final dryer 38.

[0053] The lacquer conditioning device serves to adjust the viscosity of the lacquer and the crosslinker concentration. A tempering device adjusts the viscosity and flow behavior of the UV lacquer.

[0054] The first and second lacquering units 32, 36 are each formed by a modern flexographic printing unit with a chambered doctor blade, anilox roller and plate cylinder. The anilox roller has tiny cells whose volume determines the lacquer application rate. The chambered doctor blade lies against the anilox roller, filling the cells and scraping off surplus lacquer at the same time. The anilox roller transfers lacquer to the plate cylinder which is formed by a rubber blanket in this embodiment. The rubber blanket finally transfers the lacquer to the paper-of-value sheets to be coated.

[0055] The protective layer can also be applied to a continuous web. This is preferred in particular for unprinted paper webs.

[0056] The IR-hot air combination dryer 34 used as the intermediate dryer has two dryer modules to guarantee sufficient drying even at high lacquering speed. In the final dryer 38 the UV lacquer layer is cured by irradiation with intensive UV light and the protective layer additionally dried with infrared radiation and hot air. The power and wavelength of the drying modules of the final dryer 38 is coordinated with the required wavelength of the UV lacquer and with the layer thickness on the paper-of-value sheet.